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PERFORMANCE OF SELECTED SUGAR BEET GENOTYPES UNDER HEAT STRESS CONDITIONS

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ABSTRACT

Heat stress has a negative impact on crop productivity and quality. This article aims to evaluated the performance of fifteen sugar beet genotypes were evaluated during 2021/2022 and 2022/2023 seasons at Toshka Station (Latitude 22°28'16.05"N, longitude 31°32'21.01"E and 203 m above sea level), Desert Research Center in Aswan Governorate. The experimental design was a randomized complete block design with three replicates. The results showed that mean squares sugar beet genotypes for leaves weight, root length, root diameter, root weight, and total soluble solids percentage(T.S.S.%) characters were significant in the two seasons as well as for the combined data. Mean performance of G1, G3 and G12 genotypes were the best for root weight and T.S.S%. Root weight had highly significant and positive correlation with each of leaves weight, root length, root diameter and T.S.S%. Root diameter had a significant and positive correlation with T.S.S%. The difference between the two seasons for results is due to high temperatures during second season. This is the first step of program towards selection of suitable sugar beet genotypes for Upper Egypt conditions.

Key words: ***Beta vulgaris L., Evaluation, Correlation, High temperature.***

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) has become the main source of sugar production in many countries of the world. In Egypt, there has been a significant change in the cultivated area of sugar beet. In 1982, cultivated the area of sugar beet was about ١٧000 fed, with productivity of 16,900 tons sugar. While in 2022, the cultivated area of sugar beet became 618100 fed, with productivity of 1,790,787 tons sugar. Consequently, sugar beet will become the primary source of sugar production in Egypt (Sugar Crops Board in Egypt, Dec. 2023).

Abou-Elwafa *et al* (2020) evaluated 17 sugar beet breeding lines in addition to the commercial sugar beet cultivar Kawimera under heat stress and deficit irrigation at Assiut University Experimental Farm. They found that six high-yielding lines were identified under high temperature conditions. Stress tolerance index (STI) revealed a significant and positive correlation with root and sugar yields. Dewdar *et al* (2020) studied performance and genotype × environment interaction of some sugar beet varieties grown in newly reclaimed soils. They found highly significant variation for G×E interactions was observed, suggesting that the sugar beet genotypes are highly influenced by changing in the environment. Many investigators had evaluated sugar beet genotypes under different environmental conditions. They found variation in yield performance in sugar beet genotypes (Abo-El-Ghait 1993, Al-Jbawi 2000, Abd El-Razek *et al.* 2006, Shalaby *et al* 2007, Bayomi 2013, Abd El-Razek and Ghonema 2016, Khalil *et al* 2018, Bayomi and Moustafa 2019, and Bayomi *et al* 2022). Wael *et al* (2021) studied the response of sugar beet growth, yield and yield components to compost and phosphorus fertilizers under Sudan conditions. They reported that, after 16 weeks from sowing, root diameter was ranged from 8.3 (control) to 10.8 cm (compost treatment) and root weight ranged from 569.01(control) to 934.25 g (compost + phosphorus1 treatment).

Sugar beet prefers growing in latitudes between 30° and 60° N. Though, it can be grown in diversity of climatic conditions and a range of soil types (Abou-Elwafa *et al* 2020). Sugar beet cultivation succeeded in Governorates of Upper Egypt (Assiut, Sohag, Qena and Aswan). Assiut governorate achieved the highest productivity (31tons/fed) in Egypt (Sugar Crops Board in Egypt, Dec. 2023). The objective of this study was to evaluate the performance of fifteen sugar beet genotypes (monogerm and multigerm) under environmental conditions affected by heat stress.

MATERIALS AND METHODS

The experiment was executed at Toshka Station, Desert Research Center in Aswan Governorate, during 2021/2022 and 2022/2023 seasons. Fifteen sugar beet genotypes were used in this experiment. It was obtained from plant breeding and conservation program of Desert Research Center (DRC). Two monogerm genotypes [SKC59-522(G1) and SKG58-642(G2)] and thirteen multigerm genotypes [SKC59-622(G3), SKG73-412(G4), SKH44-412(G5), SKH44-422(G6), SKH44-432(G7), SKH44-442(G8), SKH44-452(G9), SKH44-462(10), SKH44-472(G11), SKC59-422(G12), SKG73-311(G13), SKH44-482(G14) and SKT48-411(G15)] were used for evaluation under the experimental conditions.

Experimental conditions: Toshka Station (Latitude 22°28'16.05"N, longitude 31°32'21.01"E and 203 m above sea level) area lies in the arid South Egypt; it is characterized by a Sahara climate. The monthly mean air temperature (°C) was differed year to another of Toska Station (Table 1). Soil (Depth 0-30cm) was sandy, salinity 0.96 dSm^{-1}, pH 8.72 and organic matter 0.12%. Irrigation water salinity was 1.42dSm^{-1} and pH 7.43.

Table 1. Mean, maximum and minimum temperature (°C) as well as relative humidity (R. H.%) at Toshka Station during 2022 and 2023 seasons.

Month	T. Mean °C		T. Max. °C		T. Min. °C		R. H. %	
	2022	2023	2022	2023	2022	2023	2022	2023
Jan.	12.9	15.8	21.3	25.0	6.1	8.2	43.0	43.0
Feb.	15.2	15.9	25.0	25.0	7.0	8.1	38.4	35.0
Mar.	19.5	22.2	29.5	31.5	10.4	13.8	24.4	24.9
Apr.	29.2	26.5	39.6	35.7	19.4	19.4	13.3	17.7
May	31.1	30.7	40.3	39.4	21.9	21.9	14.3	17.0
Jun.	33.5	35.0	41.8	43.3	24.9	26.4	17.5	16.8
Jul.	33.6	35.0	41.7	43.5	25.4	26.3	17.8	16.6
Aug.	35.3	36.0	43.2	44.4	27.3	27.6	19.6	18.4
Sep.	33.0	34.1	41.8	42.7	24.6	25.7	20.6	19.6
Oct.	27.9	30.2	36.2	38.8	20.4	22.6	28.7	27.5
Nov.	21.3	24.9	29.5	32.6	14.4	18.1	36.0	36.7
Dec.	17.8	19.1	26.7	27.9	10.6	11.9	43.2	46.4

T. = Temperature, R.H. = Relative Humidity.

Sugar beet genotypes were planted in the 15th of October of two seasons under the high temperature conditions using a randomized complete blocks design with three replications under drip irrigation system. Plot area was 52.5 m^2 including 3rows (25m long and 70 cm wide) and 30 cm between plants. Recommended agricultural practices were applied. Harvesting was on 1-2 May of the two seasons. Leaves weight (g), root length (cm), root diameter (cm), root weight (g)) and total soluble solids percentage (T.S.S%) characters were recorded from five randomly selected plants from each genotype in a plot.

Experimental design and Statistical Analysis: Statistical procedures were done according to the analysis of variance for a randomized complete block design as outlined by Steel and Torrie (1980). The treatment means were compared using least significant difference test at 5% level of significance. The combined analysis was conducted for the data of the two season according to Cochran and Cox (1957).

RESULTS AND DISCUSSION

Analysis of variance for leaves weight, root length, root diameter, root weight and total soluble solids percentage (T.S.S%) in each season as well as the combined analysis is presented in Table 2. Sugar beet genotypes mean squares were significant for studied traits in both seasons as well as the combined data under Toshka station conditions. Mean squares of two seasons were significant for all traits except T.S.S% in the combined data.

Table 2. Analysis of variance for leaves weight, root length, root diameter, root weight and T.S.S% of fifteen sugar beet genotypes under Toshka station conditions during 2021/2022 and 2022/2023 seasons (Combined analysis of two seasons).

SOV	df	Leaves weight (g)	Root length (cm)	Root diameter (cm)	Root weight (g)	T.S.S%
Season 2022/2023						
R.	2	2528.59	4.47	2.68	195410.82	2.48
G.	14	6664.52*	13.84*	1.50*	99136.26*	9.75*
Error	28	320.25	0.304	0.409	12759.37	0.538
Season 2023/2024						
R.	2	1657.66	3.22	2.61	3780.40	2.83
G.	14	6340.09*	5.80*	1.05*	50007.13*	6.05*
Error	28	48.66	0.091	0.057	1167.16	0.095
Combined analysis						
Y.	1	11142.24*	19.60*	7.57*	436113.61*	7.11 n.s
Y.×R.	4	2093.13*	3.85*	2.64*	116606.11*	2.65 n.s
G.	14	12859.23*	17.97*	2.10*	132020.71*	15.03*
Y.×G.	14	145.08*	1.68*	0.45*	17122.68*	0.76 n.s
Error	56	184.46	0.198	0.23	6963.27	0.32

N.s, *: Non-significant and Significant, respectively. R. = Replication, G. = Genotype, Y. =Year

The interaction between years and replications mean squares was significant for all of the studied traits, except T.S.S%. Moreover, the interaction between years and sugar beet genotype mean squares was significant for leaves weight, root diameter, root length and root weight.

While, the interaction between years and sugar beet genotype mean squares was insignificant for T.S.S%. Bayomi (2013) reported that sugar beet genotypes mean squares were significant for all his studied characters. Moreover, Bayomi and Hassan (2019) reported that the interaction between sugar beet genotype and location mean squares was highly significant for all of the studied characters. Bayomi and Moustafa (2019) reported that the interaction between years, salinity and sugar beet genotype mean squares were highly significant for all studied traits.

The results presented in Table 3 show the mean performance fifteen of sugar beet genotypes under the land affected with heat stress conditions for leaves weight, root length and root diameter characters. The general average of the leaves weight trait was 180.6 and 158.3g in the first season and second season, respectively. G3, G12, G11, G9 and G5 genotypes had the highest value of this trait (246.8, 236.2, 223.1, 206.1 and 204.8g) in the first season, respectively. In the second season, G12, G3, G11, G7 and G9 genotypes recorded the highest value of the leaves weight (222.7, 219.7, 198.6, 186.2 and 181.3g, respectively). While, G13 genotype gave the lowest value of the leaves weight (77.4 and 66.0g) in the first and second season, respectively. On the other hand, G3 and G12 genotypes were the best for the leaves weight trait in the two seasons and in the combined data (Fig 1). Bayomi and Moustafa (2019) indicated that the leaves weight trait differed with different sugar beet genotypes. The general average of the root length trait was 17.6 and 16.7cm in the first and second seasons, respectively. G1, G10, G9, G3 and G7 genotypes recorded the highest value of this trait (22.7, 19.7, 19.0, 18.8 and 18.8cm) in the first season, respectively. G7, G1, G10, G3 and G12 genotypes had the highest values of the root length (18.6, 18.5, 18.0, 17.6 and 17.5cm) in the second season, respectively. While, G8 genotype gave the lowest value of the root length (13.9 and 13.9cm) in the first and second season, respectively. Moreover, G1 and G10 genotypes were the best for the root length trait in the two seasons and in the combined data (Fig 2). The general average of the root diameter trait was 12.0 and 11.5 cm in the first and second seasons, respectively. G12, G7, G3, G11 and G1 genotypes had the highest values of this trait (13.2, 13.2, 12.9, 12.6 and 12.5cm) in the first season, respectively.

G12, G7, G3, G11 and G8 genotypes had the highest value of the root diameter (12.6, 12.2, 12.0, 11.9 and 11.8cm) in the second season, respectively. While, G13 genotype gave the lowest value of the root diameter (11.0 and 11.2cm) in the first and second season, respectively. In general, G12 and G7 genotypes were the best for the root diameter trait in the two seasons and in the combined data (Fig 3). The difference between the two seasons for leaves weight, root length and root diameter is due to high temperatures during second season (Table 1). Many investigators indicated that the root length and root diameter traits differed with different sugar beet genotypes and experimental environments (Bayomi 2013, Bayomi and Hassan 2019, Bayomi and Moustafa 2019, Bayomi 2024).

Table 3. Mean performance for leaves weight, root length and root diameter of fifteen sugar beet genotypes under Toshka station conditions during 2021/2022 and 2022/2023 seasons.

Genotypes	Leaves weight (g)		Root length (cm)		Root diameter (cm)	
	S_1	S_2	S_1	S_2	S_1	S_2
G1	161.3	137.8	22.7	18.5	12.5	11.3
G2	166.1	142.6	14.3	14.4	11.5	11.5
G3	246.8	219.7	18.8	17.6	12.9	12.0
G4	203.7	158.5	16.8	16.5	11.4	11.0
G5	204.8	173.8	18.2	17.5	11.8	11.5
G6	173.5	164.5	17.5	15.9	11.9	10.4
G7	192.4	186.2	18.8	18.6	13.2	12.2
G8	172.8	156.8	13.9	13.9	11.7	11.8
G9	206.1	181.3	19.0	17.4	12.1	10.9
G10	204.4	177.8	19.7	18.0	11.7	10.8
G11	223.1	198.6	16.8	16.2	12.6	11.9
G12	236.2	222.7	17.9	17.5	13.2	12.6
G13	77.4	66.0	16.9	16.3	11.0	11.2
G14	102.1	75.9	17.4	16.9	11.2	11.0
G15	137.8	112.5	16.0	15.4	11.7	11.6
Mean	180.6	158.3	17.6	16.7	12.0	11.5
LSD 0.05	29.93	11.67	0.92	0.51	1.07	0.40

S_1 = 2022/2023 season S_2 = 2023/2024 season.

Fig. 1. Sugar beet genotypes in combined data for leaves weigh per plant.

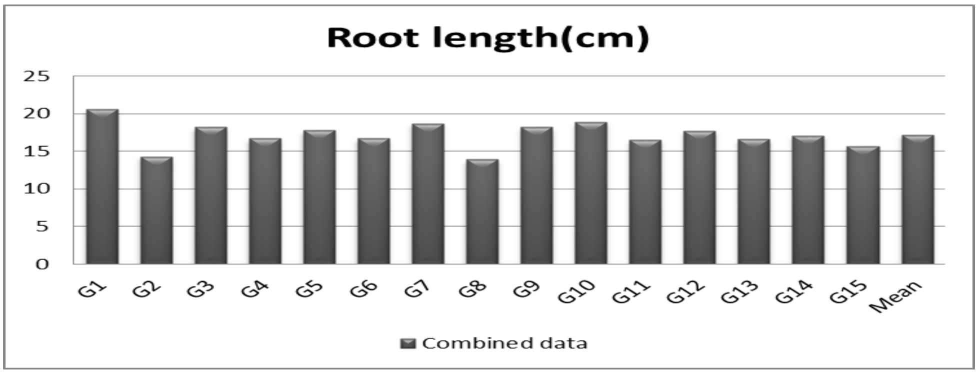

Fig. 2. Sugar beet genotypes in combined data for root length.

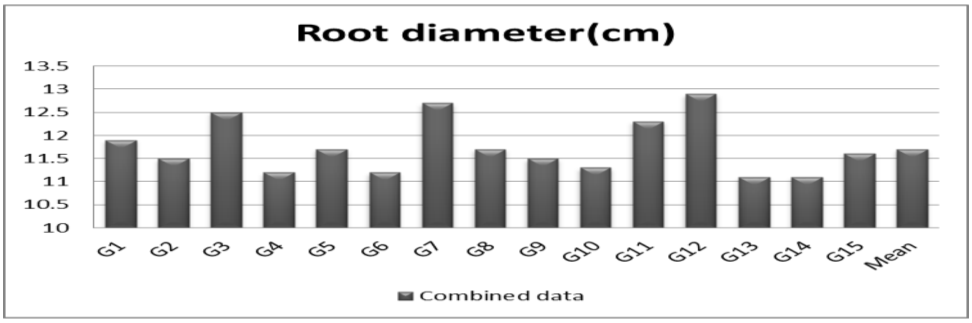

Fig. 3. Sugar beet genotypes in combined data for root diameter.

The results presented in Table 4 show the mean performance of fifteen sugar beet genotypes under the land affected with heat stress conditions for root weight and total soluble solids percentage characters. The general average of the root weight was 1338.1 and 1198.9g in the first and second seasons, respectively. G1, G3, G12, G9 and G7 genotypes had the highest values of this trait (1630.0, 1630.0, 1473.3, 1470.7 and 1456.3g) in the first season, respectively. G3, G1, G12, G5 and G7 genotypes had the highest value of the root weight (1426.7, 1376.7, 1341.7, 1333.7 and 1301.3g) in the second season, respectively. While, G13 and G4 genotypes had the lowest value of the root weight (1084.0 and 1000.3g) in the first and second seasons, respectively.

Table 4. Mean performance for root weight and T.S.S% of fifteen sugar beet genotypes under Toshka station conditions during 2021/2022 and 2022/2023 seasons.

Genotypes	Root weight (g)		T.S.S%	
	S_1	S_2	S_1	S_2
G1	1630.0	1376.7	23.9	21.9
G2	1122.3	1153.7	20.4	20.9
G3	1630.0	1426.7	23.6	22.2
G4	1130.0	1000.3	17.7	18.2
G5	1430.0	1333.7	20.0	19.8
G6	1293.3	1028.0	19.3	18.6
G7	1456.3	1301.3	21.1	20.5
G8	1119.0	1065.7	21.9	21.3
G9	1470.7	1165.7	22.5	22.0
G10	1442.3	1153.7	19.4	19.4
G11	1290.0	1183.3	21.2	20.3
G12	1473.3	1341.7	22.7	22.4
G13	1084.0	1121.3	19.7	19.3
G14	1270.0	1185.6	22.4	20.8
G15	1230.0	1145.7	22.9	22.7
Mean	1338.1	1198.9	21.3	20.7
LSD 0.05	188.92	57.14	1.23	0.51

S_1 = 2022/2023 season S_2 = 2023/2024 season.

On the other hand, G3 and G1 genotypes were the best for the root weight in the two seasons and in the combined data (Fig 4). The difference between the two seasons for root weight is due to high temperatures during second season (Table 1). The general average of the total soluble solids percentage (T.S.S%) trait was 21.3 and 20.7% in the first and second seasons, respectively. G1, G3, G15, G12 and G9 genotypes recorded the highest values of this trait (23.9, 23.6, 22.9, 22.7 and 22.5%) in the first season, respectively. G15, G12, G3, G9 and G1 genotypes recorded the highest values of T.S.S% (22.7, 22.4, 22.2, 22.0 and 21.9%) in the second season, respectively. Moreover, G1, G15 and G3 genotypes were the best for the T.S.S% trait in the two seasons and in the combined data (Fig 5). The genetic differences in most traits among sugar beet genotypes have been reported by Abd Alla (1992), Al-Jbawi (2000), Abd El-Razek *et al* (2006), Aly (2006), Allam *et al* (2007), Nasr and Abd El-Razek (2008), Bayomi (2013), Abd El-Razek and Ghonema (2016), Bayomi (2018), Khalil *et al* (2018), Abou-Elwafa *et al* (2020), Bayomi *et al* (2022) and Bayomi (2024).

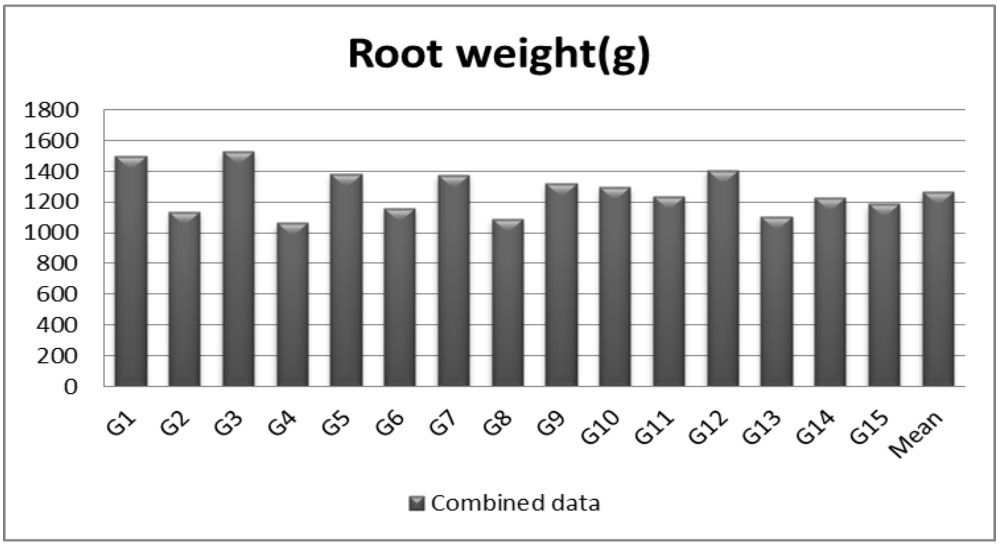

Fig. 4. Sugar beet genotypes in combined data for root weight.

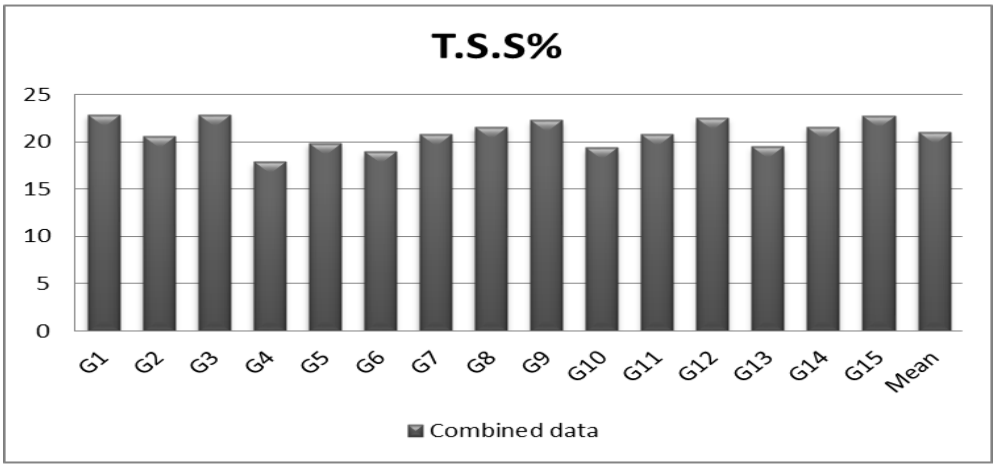

Fig. 5. Sugar beet genotypes in combined data for total soluble solids.

The results presented in Table 5 revealed the associations among leaves weight, root length, root diameter, root weight and T.S.S% traits of sugar beet genotypes under Toshka station conditions across the two seasons. In that context, leaves weight had highly significant and positive correlation with each of root length, root diameter and root weight. In the contrary, a positive correlation but non- significant was found between leaves weight and total soluble solids percentage. Highly significant positive correlation was observed between root length and each of root diameter and root weight. On the other hand, root length showed non- significant and positive correlation with total soluble solids percentage. Root diameter had highly significant and significant positive correlation with root weight and total soluble solids percentage. This result is compatible with Bayomi and Hassan (2019). As the diameter of the root increases, the number of sugar storage rings in the root increases, and thus the sugar content increases. Highly significant and positive correlation was observed between root weight and total soluble solids percentage. Bayomi and Hassan (2019) reported that non- significant and negative correlation between root weight and total soluble solids percentage. On the other hand, Abou-Elwafa *et al* (2020) found a positive correlation between root and sugar yields.

Table 5. Pearson product moment correlation coefficients between five characters of sugar beet under Toshka station conditions for the data combined analysis.

Characters	Leaves weight	Root length	Root diameter	Root weight	T.S.S%
Leaves weight	**1.000**	**0.305****	**0.568****	**0.506****	**0.075 n.s**
Root length		**1.000**	**0.426****	**0.760****	**0.150 n.s**
Root diameter			**1.000**	**0.757****	**0.248***
Root weight				**1.000**	**0.347****
T.S.S%					**1.000**

Ns, *, **: Non-significant, Significant at 0.05 and 0.01 probability levels, respectively.

CONCLUSION

This is the first step of plant breeding and conservation program towards selection of suitable sugar beet genotypes for Upper Egypt conditions. G3 genotype had the highest values of leaves weight. G1 genotype had the highest values of root length in under the high temperature conditions. In general, the G1, G3 and G12 genotypes performed the best in root weight and T.S.S%. Root weight had highly significant and positive correlation with each of leave weight, root length, root diameter and total soluble solids percentage. Root diameter had a significant and positive correlation with total soluble solids percentage. As the diameter of the root increases, the number of sugar storage rings in the root increases, and thus the sugar content increases. It is recommended that this study to be replicated in other locations in Upper Egypt.

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أداء التراكيب الوراثية المنتخبة من بنجر السكر تحت ظروف الإجهاد الحرارى

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١. وحدة التربية – قسم الاصول الوراثية – مركز بحوث الصحراء

٢. وحدة المحاصيل – قسم الانتاج النباتي – مركز بحوث الصحراء

الإجهاد الحرارى له تأثير سلبى على إنتاجية المحصول وجودتة. ويهدف هذا البحث لتقييم أداء ١٥ تركيب وراثى منتخب من بنجر السكر بمحطة بحوث توشكى التابعة لمركز بحوث الصحراء بمحافظة أسوان خلال موسمى النمو ٢٠٢١/٢٠٢٢ و٢٠٢٢/٢٠٢٣ . كان التصميم الاحصائى المستخدم هو القطاعات الكاملة العشوائية فى ثلاث مكررات. أشارت النتائج الى وجود تباينات معنوية بين التراكيب الوراثية لجميع الصفات بكلا الموسمين والتحليل المشترك. كان متوسط أداء التراكيب G1 و G3 و G12 هوالافضل لصفتى وزن الجذر ونسبة المواد الصلبة الذائبة الكلية. وجد إرتباط موجب وعالى المعنوية بين صفة وزن الجذر وكلاً من صفات وزن الاوراق وطول الجذر وقطر الجذر ونسبة المواد الصلبة الذائبة الكلية. وأيضاً يوجد إرتباط موجب ومعنوى بين صفتى قطر الجذر ونسبة المواد الذائبة الكلية. وهذا يمثل الخطوة الاولى فى البرنامج نحو إنتخاب تراكيب وراثية من بنجر السكر تناسب ظروف صعيد مصر.

المجلة المصرية لتربية النبات ٢٨ (٣): ٣٦٥- ٣٧٧ (٢٠٢٤)